Concentrations of Leachable Phosphorus, Carbon and Nitrogen in Urban Tree Species

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Introduction

Urban lakes often suffer from eutrophication. Previous studies have found that major sources of nutrients contributing to the eutrophication could be lawn runoff and street dirt (Waschbusch 1999). It has been found that another significant source of excess nutrients to lakes could be coming from a different source: leaf litter from trees (McCombs 2007). Nutrients from leaves in natural environments have the opportunity to leach into soil before reaching lakes, but due to the imperviousness of urban roads, urban tree leaves are washed into storm drain systems, contributing a significant amount of nutrients to lakes' eutrophication (Hobbie 2013).

Previous studies have been done related to leaching potential of leaf litter nutrients. Uselman focused on analyzing the total concentrations of carbon, nitrogen, and phosphorus in 5 different species of tree leaves (Uselman 2012), while Oiu and McComb looked only at phosphorus leaching potential of leaves in wetland areas (Qiu 2002 McComb 2007). Dorney focused on cities and analyzed phosphorus leaching in thirteen different species of tree leaves in urban environments (Dorney 1986) much like the project I'm proposing. This research has had large implications for management of leaf litter reaching storm drains, suggesting that street sweeping could prevent the amount of leaves and the nutrients they carry from reaching lakes. My research expands upon this base of knowledge by analyzing the amount of carbon, nitrogen, and phosphorus that is leached from leaf litter of 27 different tree species and non-leaf matter (such as seeds) from 7 different tree species and how they compare, which will allow for an understanding of which urban tree species contribute the majority of nutrients to lake eutrophication. This new knowledge could offer implications on ideal urban tree selection to minimize contribution to eutrophication.

Methods

Leaf Leaching Protocol

Three sets of leaf samples and other plant matter from 27 different tree species were collected. Samples were weighed out to be at 5 grams. The sample was leached in 500 ml of nanopure water, or, in the case that less than 5 grams (minimum 2 grams) were available, the respective amount of water needed to maintain the 1g sample: 100 ml nanopure ratio. The leaching took place in a 1L nalgene bottle. For the first ten seconds, the container was gently shaken to allow the sample's full surface area to be exposed to the nanopure, and then was allowed to sit for the remainder of 30 minutes. At the end of the time, the mixture was once again gently shaken to homogenize before extracting 60 mls of the leachate with a syringe, filtering it through an ashed glass fiber filter (size F) placed on the syringe tip, which was divided in two 30 mL plastic bottles for storage.

Nutrient Analysis

Phosphorus standards were made from KH_2PO_4 stock, and potassium persulfate was added to the samples and standards for absorption to be read at 880nm in the spectrophotometer.

Carbon and nitrogen analysis was done together on the Shimadzu TOC analyzer.

Results

The results of the analyses are listed in Table 1. For many species, there was insufficient matter collected to run more than a single sample per species. These do not have standard errors. Similarly some samples did not have enough sample to run a specific nutrient analysis. For the phosphorus analysis, a linear trend fit the standard curve for lower concentrations well, but for concentrations higher than approximately 1.5 ppm the standard curve needed to be fit to a polynomial trend.

Highest Phosphorus Concentration	Highest Carbon Concentration	Highest Nitrogen Concentration
Tilia cordata mature seeds	*Quercus palustris* (litterand flowers)	*Tilia cordata* Mature Seeds
Quercus palustris litter	*Tilia cordata* mature seeds	*Quercus palustris* (litter and flowers)
Quercus rubra litter	*Quercus macrocarpa* litter	*Quercus macrocarpa* litter
Syringa reticulata litter	*Acer saccharinum* Ripe Samaras	*Quercus rubra* litter
Tilia cordata litter	*Acer saccharum* litter	*Tilia americana* litter

Table 1: Table comparing the species that were found to have the highest concentrations of nutrients. Matter type is only specified for non-leaf matter species, or species in which both leaf and non-leaf matter had the highest concentration of a given nutrient.

Lowest Phosphorus Concentration	Lowest Carbon Concentration	Lowest Nitrogen Concentration
Betula nigra litter	*Tilia cordata* litter	*Quercus bicolor* litter
Fraxinus pennsylvanica (litter and flowers)	*Quercus bicolor* litter	*Quercus alba* litter
Quercus palustris green acorns	*Quercus palustris* green acorns	*Quercus palustris* green acorns
Ostrya virginia litter	*Syringa reticulata* litter	*Populus deltoides* litter
Gleditsia triacanthos litter	*Populus deltoides* litter	*Ostrya virginia* litter

Table 2 (above):: Table comparing the species that were found to have the lowest concentrations of nutrients. Matter type is only specified for non-leaf matter species, or species in which both leaf and non-leaf matter had the highest concentration of a given nutrient.

Species	P Leached per gram	Std error	C Leached per gram	Std Error	N Leached per gram	Std Error
Acer freemanii litter	0.1037	0.564	26.0008	161.272	0.6659	4.142
Acer ginnala litter	0.0631	0.442	25.8571	0.492	0.3205	0.039
Acer platanoides litter	0.1169	0.547	15.4807	9.934	0.3465	0.346
Acer platanoides mature seeds	0.1304	0.349	10.5931	11.359	0.2768	0.172
Acer platanoides Ripe Samaras	0.0875	0.464	10.7374	17.076	0.3047	0.304
Acer rubrum litter	0.1249	0.276	26.1538	100.173	0.6133	1.518
Acer saccharinum litter	0.2001	0.05	9.1296	19.988	0.279	0.216
Acer saccharinum ripe samaras	-	-	28.287	26.26	0.3401	0.108
Acer saccharum litter	0.1374	0.106	29.646	n/a	0.8245	n/a
Acer saccharum mature seeds	0.2454	n/a	6.97	13.744	0.2439	0.253
Amelanchier arborea litter	0.243	1.023	8.9832	40.486	0.3867	1.316
Aesculus hippocastunum litter	0.1328	0.362	6.9996	15.768	0.3268	1.016
Betula nigra litter	0.0445	0.152	4.7054	1.387	0.2021	0.05
Celtis occidentalis litter	0.0562	0.135	25.3627	32.735	0.6108	0.807
Celtis speciosa litter	0.109	0.383	5.7215	n/a	0.2701	n/a
Fraxinus americana litter	0.0506	n/a	8.4944	n/a	0.3269	n/a
Fraxinus pennsylanica litter	0.0367	n/a	8.8241	32.401	0.2174	0.287
Fraxinus pennsylanica male flowers	0.0349	0.131	13.9627	13.707	0.4195	0.38
Ginko biloba litter	0.2193	0.664	11.4711	8.598	0.1093	0.098
Gleditsia triacanthos litter	0.0491	0.068	8.0946	11.596	0.079	0.129
Grass	0.2307	1.424	48.813	129.884	0.5297	0.806
Ostrya virginia litter	0.0092	n/a	6.9507	n/a	0.0588	n/a
Phellodendron amurense litter	0.2605	0.767	9.8539	12.605	0.1959	0.251
Populus deltoides litter	0.1377	0.479	2.6546	10.323	0.0576	0.427
Populus deltoides male flowers	0.123	0.171	5.5811	2.05	0.0953	0.126
Quercus alba litter	0.0825	0.077	3.4188	1.1929	0.0401	0.057
Quercus bicolor litter	-	-	1.40225	0.746	0.0049	0.024
Quercus macrocarpa litter	-	-	55.0208	n/a	3.095	n/a
Quercus palustris litter	3.0389	n/a	99.811	n/a	4.926	n/a
Quercus palustris green acorns	0.0301	0.006	1.7796	n/a	0.0489	n/a
Quercus palustris male flowers	0.058	n/a	34.5835	n/a	2.1926	n/a
Quercus rubra litter	1.903	n/a	25.4925	85.412	2.4122	14.279
Syringa reticulata litter	0.6844	n/a	2.33	2.036	0.0827	0.088
Tilia americana litter	0.3239	0.789	20.393	57.867	1.9068	7.709
Tilia cordata litter	0.5528	n/a	1.0284	0.397	-	n/a
Tilia cordata mature seeds	4.5883	n/a	96.3889	n/a	12.7134	n/a
Ulmus americana litter	0.3073	n/a	7.0497	n/a	0.1823	n/a

Table 3: Table comparing species and matter type by leachable phosphorus, carbon, and nitrogen concentrations. Standard error Is immediately left of each corresponding analysis. Analyses run on a single sample where not given a standard error. The "-" sign marks an omitted analysis due to lack of remaining sample matter.

Conclusions

It is important to notice the compiled data only applies to the amount of leachable nutrients. Although green acorns from *Quercus palustris* were on all three lowest nutrient concentration lists, its leaves were on all three of the highest nutrient concentration lists, and its flowers on the highest carbon and nitrogen concentration lists. It is likely that there were large differences in how readily nutrients were leached from different plant parts due to surface area differences.

Standard errors were unfortunately quite high for many of the samples. Samples of the same species that were collected at different locations varied greatly. This could be due to different amounts of fertilizers used in different locations, that may have leached into the fallen leaves themselves.

The results do demonstrate that a significant amount of nutrients comes from the leaves. Comparing the amounts of nutrients from the fallen leaf matter with the amount of nutrients found in grass suggests that many tree species deposit a quantity of nutrients comparable with grass, the runoff from which has already been a focus of those attempting to prevent eutrophication. The data may have implications for urban city-planners who hope to prevent eutrophication of city lakes.

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